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"The Importance of Accurately Modelling Light Scattering in Luminaire Design"

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Abstract

The reflected and transmitted scattering of light in a luminaire can play a major role in the performance of the luminaire. Many times, this is the reason the actual luminaire performance does not match the results predicted in optical modelling, design, and analysis software. This paper, looks at the causes of light scattering in a luminaire, for example, scattering due to the surface roughness of reflectors. Diffusers can also produce scattered light, both transmitted and reflected. Modelling this scattered light is a key factor in obtaining accurate computer models and performance predictions during the design and development process. We will also look at how scatter is measured and how these measurements can be used to make accurate properties for use in computer modelling phase of the design process.

1. What is Scattering?

Scattering is a general physical process where some forms of radiation, such as light, sound, or moving particles, are forced to deviate from a straight trajectory by one or more localized non-uniformities in the medium through which they pass. In conventional use, this also includes deviation of reflected radiation from the angle predicted by the law of reflection. Reflections that undergo scattering are often called *diffuse reflections* and unscattered reflections are called *specular* (mirror-like) reflections. [1] Scattering can vary as a function of wavelength, incident angle, and temperature.

In an ideal world, we could model everything as a perfectly specular mirror, a perfectly diffusing surface, a perfectly transmitting surface, or a perfectly absorbing surface. These options exist in software, but not in real life. Scattering can be a tool for the luminaire designer to use when designing a new luminaire. A key factor though is having accurate measurements of the surface and bulk media scattering and using them properly in optical design and analysis software.

In luminaire design, there are two types of scattering that can be of concern; surface scattering and bulk scattering. Surface scattering is scattering that occurs on the surface of an object. This can be reflected or transmitted scattering. Surface scattering is due to roughness or texturing applied to the surface of a material. This could be due to roughness from the manufacturing process for the material, such as machining or tool marks, or due to a texture applied to the surface by design. Surface scattering is found and used on optical elements such as reflectors, diffusers, backlight light extraction, light guide texturing, and many other applications. Lens surfaces also have scattering due to roughness and manufacturing defects such as scratches. Examples of surface scattering are coatings, paints, diffusers, polished surfaces, etc…Most of this paper will focus on surface scattering, how it is measured, and how it is modelled.

The second type of scattering is called bulk scattering. This is scattering inside of an object, typically by impurities, or by particles added to the material to induce scattering. Bulk scattering occurs in light guides where diffusing materials have been added to the plastic or glass, or by infusing air bubbles into the material, or with textured shapes in volume diffusers. Examples of bulk scattering include human tissue, fluids, opaque materials, etc…

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